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Bio-Scape Energy Solution to Transport Induced Climate Change in Lagos Metropolis, Nigeria.

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Abstract— ***This paper assessed the potential of integrating marginal land resources and landscape urbanism in biofuel production as a climate change mitigation option in Lagos metropolis. To achieve this view, three level methodological steps were adopted as follows; first, extraction of potential marginal lands from 5 sub-types of land use dataset using Arc GIS mapping system according to a set of criteria, followed by estimation of energy value of the identified marginal lands and lastly, a case scenario analysis of substituting fossil fuel in Bus Rapid Transit (BRT). The outputs revealed a spatial distribution of combined system of linear utilities with setbacks amounting to over 30,850 hectares. At full planation of Jatropha, the marginal lands yielded approximately 37,020 tonnes of Jatropha oil per year, 3072.2 liters of bio-diesel and a gross profit of N12, 131, 898, 240 annually at N128 diesel pump price. The step 3: showed that on 36,892,800km annual mileage, BRT buses in Lagos consumed 22, 873, 536 emit 17,192,044 800g of CO_2 while a standing Jatropha seed sequestrate 557, 278.60g CO_2 ha-1 yr-1.In conclusion, the* study proposed *integration of Jatropha in the design of Lagos metropolitan landscape. Consequently, resultant landscape restoration on the eco-sensitive marginal lands is expected to repair the fragmented city ecological structure and revamp the natural processes as well as enhance biofuel production and subsequently empowers carbon sequestration and resolve the climate change serendipity hoofing around the city's future.***

Keywords— Bio-scape, biofuel, climate change, energy and Landscape urbanism

1. Introduction

This Experience, studies and narrative discourse have shown that in different ways, the global economy, global population and the pattern(s) of global energy consumption through transportation are skewed towards fossil fuel and are intrinsic in cities. As asserted by Urry in 2012, 95% of all city transportation energy is oil-based which possibly explains why cities produce 75% of the world's CO_2 emissions (Jain, 2012). Currently 85% of the world's energy demand is met by combustion of fossil fuels which are depletable and account for over 80% of greenhouse gas (GHG) emission. The resultant outcomes manifest as pollution; energy and resources depletion; greenhouse gas infiltration into the atmospheric environment-leading to global warming and subsequent climate change; food insecurity and poor quality of life. These civilization problems are held to be the principal impact of transport fossil fuel on urban landscape. They manifest by defragmenting urban ecological properties that are usually provided by gorge, wetlands, streams and overhead line setbacks (utility systems). At urban scale, many studies have concluded that providing bio-ecological based solution to these problems will depend on the management of these utility systems.

United Nation's state of cities report (2012), Agbro and Ogie, (2012) respectively show that by 2050, 75% of the world population will live in cities. Amidst these facts, global energy demand is expected to grow to about 50% by 2025 and a major part of this increase is expected to come from emerging economies where 85% of the projected global population will be living in 2025. According to VTT Technical Research Centre (2009) the ensuing and projected outcomes are environmentally intensive, will contribute to global warming, promote climate change and cathartically generate global concern on urban landscape. These facts mean that "the nature of cities will have an incredibly important impact on the nature of life on this planet" (Urry, 2012). Therefore, ensuring the future of cities require the protection and enhancement of existing urban landscape. This view has been firmly collaborated by UNHABITAT in 2011, when she noted that "the lives and livelihoods of hundreds of millions of people will be affected by what is done (or not done) in urban centres with regard to adapting to climate change over the next decade"

Achieving sustainable city environment in this regard requires an integrated approach involving sustainable energy use, optimal land use planning, adequate transport and micro socio-economic planning policies at both urban and sub urban levels (UNEP, 2007).This option aligns with the tenets of landscape urbanism paradigm shift in thinking towards urban landscape systems that interact across environmental and human conditions, suggesting that these larger systems of ecological, social and geological processes create the background for understanding urbanization and human habitation around the world. As suggested by Hanna (2011), a holistic interdisciplinary approach, united by the idea of landscape as a model for urbanism, will support the creation of sustainable cities. These assertions portray that landscape and ecological systems play an important role in creating healthy, productive and integrative urban frameworks. Therefore biofuels (an integral bio-product of landscape vegetation) are considered in part, a solution to such issues as sustainable development, energy security and a reduction of greenhouse gas emissions.

Thus, in confronting the challenges of fossil fuels depletion, and erratic climate change, it is necessary for the city of Lagos (and other contemporary cities) to develop and implement urban energy management solutions that align with ecological planning in line with key global issue (World Bank, 1992). This approach requires overlaying the sustainable concept of productive urban landscapes with the spatial concept of continuous landscape to change the appearance of contemporary cities towards an unprecedented naturalism (Bohn and Viljoen 2009).

Using Lagos metropolis as a case study, this paper explains the integration of second generation bio-fuel production methodology with landscape urbanism using marginal land resources in the metropolis. This will contribute to subsisting fossil fuel in Bus Rapid Transit (BRT) system in the city.

Researchers are actively studying the potentials of biofuels as renewable energy source, and there is not yet a firm consensus on these (Dale, et al. 2010). Biofuel production proponents argue that the increased use of biofuels produced domestically will result in increased farm incomes, greenhouse gas reductions, and national energy security (Paltsev et al., 2005; Reilly and Paltsev, 2007 and Gurgel, Reilly and Paltsev, 2008). Further review of related materials on Bio-scape energy solution to transport induced climate change show that, there have been an extensive study on ecological based planning and design solution to transport induced climate change with concentration on the following themes; biofuel production and policies, climate change, sustainable development, marginal land resources and landscape urbanism.

From the angle of biofuel production, several research efforts towards renewable alternative energy to fossil fuel such as Agbro and Ogie (2012), Ugochukwu, (2010), Bamikole et al (2008), and Leo, et al 2007, have shown that biofuel is a suitable alternative energy which applies to solid, liquid or gaseous fuel produced from biological materials (biomass). It can also be used for the generation of power, heat or fuel for motive power. These research results necessitated the quest in probing into the availability of these biomass resources and its potential for economic development with less impact.In recognition of the advantages of second generation biofuel production much attention has been paid to woody oil plants, among which Jatropha (a multipurpose shrub or small tree commonly used for fencing, erosion prevention and land reclamation) is considered a promising feedstock species for biodiesel production.

Despite the above tenable solutions to climate change, offered by renewable alternative energy (biofuel), marginal lands, sustainable development, adaption and mitigation, no concrete solution exist in literature, most especially at urban scale. For example, none of these literatures examined the availability of infrastructure at city level to coordinate the various ecological based solutions. Hence the favoured area for further discussion and literature study is landscape urbanism. Hanna in 2011 while advocating for Landscape urbanism opines that the holistic interdisciplinary approach, united by the idea of landscape as a model for urbanism, will support the creation of sustainable cities. According to her landscape urbanism embraces the human and environmental processes that influence city creation, development and longevity. Many authors define it as a shift from the urban "building block" of architecture to the "structuring medium" of landscape. Steiner, (2006) defined landscape urbanism as a synthesis of natural and social processes that gives rise to a new urbanism grounded in ecological literacy, where people are viewed as part of nature. Wall, (1999b) suggested that landscape urbanism invokes the functioning matrix of connective tissue that organizes not only objects and spaces but also the dynamic processes and events that move through them. Landscapes urbanism focuses on systems that interact across environmental and human conditions, suggesting that these larger systems of ecological, social and geological processes create the background for understanding urbanization and human habitation around the world. Landscape and ecological systems play important role in creating healthy, productive and integrative urban frameworks.

This study therefore focuses on the use of this Jatropha as an alternative to fossil fuel in mitigating climate change

2. Study Area and Research Methodology

Lagos state is located on the South-Western part of Nigeria with the southern boundary of the state framed by about 180 kilometer along Atlantic coastline while the northern and eastern boundaries are framed by Ogun State. Lagos state according to Ehingbeti (2012) has a population of 20.5million while Lagos State Census (2006) and UN-Habitat population projection (2010) puts the population of Lagos at 20.19million and 24.6million projection for 2015 respectively. The state stands at apopulation densityof 20,000 persons/Sq. Km, a population growth ratethat lies between 6-8% (Nigeria = 2.9%, Jakarta 3.1%, Tokyo 0.3% and Shanghai 0.1%) and annual population growth of600,000 (10 times New York) (United Nation, 2010)

Lagos metropolis comprises 88.7 % of Lagos state population. According to George (2010) metropolitan Lagos which presently takes up about 37% of the area of Lagos State; is home to over 85% of the state population, and covers an area of about 1,183 km^2 out of the 3,577km^2 total area of Lagos State. Littoral climatic variables prevail throughout the year with average daily maximum temperature of about 30°C and 29 mill bars of vapor pressure in the air at critical sunny dry season days. Morphologically, this bioregion is framed by interconnecting creeks and lagoon that run parallel to the Atlantic shoreline.

A three level methodology were adopted for the study as follows; Step 1: Identification of marginal land. Marginal lands which were suitable for growing the energy plants were identified from 5 sub-types of land use dataset according to a set of criteria. The outputs of this step were total amount and spatial distribution of marginal land in Lagos Metropolis. Step 2:estimating the energy value of the estimated marginal lands. Step 3: case scenario analysis of substituting fossil fuel in BRT with biodiesel.

3. Research Result

From logical examination of the research aim the research data were analysed under each of the proposed research objectives as follows;

The first was identification of marginal land resources in Lagos metropolis and evaluation of their landscape urbanism potential. According to Akinmoladun and Adejumo (2005) the city of Lagos planning concept presents a metropolis that is made up of many townships shaped by natural drainage ways and wet lands, Nigeria Rail way Corporation (NRC) line, Power Holding Company of Nigeria Plc.'s high tension cables (132 and 330 KVA) and other utility lines with broad right of ways (Figure 1. The setbacks on these tertiary drainage systems constitute what this study recognised as marginal lands. Thus applying Harris et al. (1996) principle for assessing potential uses of land and water resources, four principal considerations was used to analyze the best use of system setbacks compared to the current uses. These include economic returns, social pressures, cultural attachment and maximization of agricultural productivity. In addressing this objective evidence from secondary geographic information obtained from Lagos State Digital mapping and Geographic Information System (updated through personal observation) enhanced the result of the digital map analysis shown in table 1 below.

Figure 1: Land use analysis of Lagos metropolis showing existing utility systems

Table1: Estimated Marginal land resources in Lagos metropolis.

S/N	Utility System	Land resources (Ha)	Percentage (%)	Current uses
1	Drainage Channels (Systems 1 to 6)	28,405	92.1	Illegal encroachment/ refuse dump
2	State Arterial (ROW)	125	0.4	Refuse dump prominent
3	Vacant city plots	75	0.24	Private ownership-generally inaccessible to the populace
4	Nigeria Railway Corporation's rail line	126	0.41	Illegal Trading at terminals and squatters' temporary sheds along the rail line
5	Federal highway (ROW)	202	0.65	Waste dumps (Refuse, abandoned vehicles, containers, auto mart etc.)
6	Power Holding Authority (ROW)	1,917	6.21	Illegal encroachment by illegal structures houses, motor parks, markets, mechanic workshops etc.
	Total	**30, 850**	**100**	

Source: Akinmoladun and Adejumo (2005)

Table 1 shows the result of a desktop review of Akinmoladun and Adejumo (2005) scenario study on the potential of land and water resources for urban agriculture in metropolitan Lagos. The drainage channels (system 1 to 6) which have a total length of 112.26 km (See World Bank Assisted Lagos Drainage and Sanitation Project, 1998 and Akinmoladun and Adejumo, 2005) and a minimum required setbacks or right of way of 30m from each side of a drainage channel collectively, provide an estimated area of (112.22 × 1,000 × 60)/10,000 = 673.01 hectare of land (if the enabling laws are enforced). Other hectares of potential marginal lands offered as set-backs from utility systems like state arterial roads (ROW), vacant city plots, federal highway (ROW) are 125, 75 and 202 respectively. The study also revealed that 30 km of Nigeria Railway Corporation's dual carriage rail line stretching from Iddo terminus in the south to Agege in the north with a minimum allowable set back of 21m on both sides (Lagos State Government, 1986, 2005) offers 126 ha of land. These hectares of land have potential for integrated bio-scape energy solution using Jatropha feedstock production (table 2).

This is in addition to the over 35ha adjoining setbacks and buffer area to water bodies within the metropolis suitable for urban landscape. The legal set back from water bodies in the city include 150m from the ocean, 75m from lagoon shoreline, 60m from rivers and 15m from canals (Lagos State Government, 1986, 2005). Evaluation of these marginal lands for landscape urbanism revealed that a combined system of these linear utilities possesses a set-back amounting to over 30,850 hectares of land that is either lying idle or are occupied by illegal structures and waste dumps. A situation scientifically believed to be responsible for the environmental deterioration of adjoining residential and other land uses, ecological malfunctioning of the river and stream systems, aesthetically unpleasant, economically wasteful and socially ghettoizing. From assertion made by Shane in 2004 that all of landscape urbanism's triumphs so far have been in such marginal and "unbuilt" locations, this paper finds it tenable to concur that such marginal lands more especially when they crisscross the urban space is a veritable tool for conceptualizing and engaging the city and its landscape as a hybridized, natural and chaotic ecology for interpreting and then representing landscape systems so that these systems can in turn influence urban forms, process and patterns.

Table 2: Identification of biomass energy resources potential of the marginal lands using Jatropha as non agricultural feedstock

S/N	Parameters	Jatropha Site requirements	Site Characteristics of existing Marginal Land	Sources
1	Native distribution	Pantropical distribution	Lagos is a tropical region	(Henning, 2006)
2	Soil Type	Wide range of soils.	Sandy mud	(Foidl*et al.* 1996; Heller 1996; okunsipe, 2005).
3	Environmental conditions	Humid	Rarely below 60%.	(Achten, 2010)
4	Temperature	20°C and 28C°	Average 24^0C	(Heller 1996; Makkar*et al.* 1997;
5	Rainfall	250 mm and 3000 mm	250-300mm	(Foidl*et al.* 1996).
6	Altitude range	from sea level up to 1800m	3-10m	(Achten et al, 2008)
7	Surface slope	should not exceed 30°	Average slope is 10^o	(Tewari 2007).
8	Soil Ph.	should not exceed 9	7	(Biswas *et al.* 2006; Tewari 2007)
	Total	**30, 850**	**100**	

Sources: Desktop Study, (2013)

A summary assessment of potentials of the identified marginal lands as shown on table 2 revealed that they are all for bio-fuel stock which guarantees improvements on their economic returns, agricultural productivity, enhances social coherence and harmonizes cultural attachments.

From table 2 above Jatropha has a pantropical distribution as reported by Henning in 2006. Also outside Henning's report, Olaniyi, from Centre for Jatropha Promotions & Biofuels (CEJAB) reported in 2007 that Jatropha plants are widely found in Nigeria. The local names in Nigeria are 'botuje', 'pupa', 'lapalapa pupa', 'iyalode pupa', 'sherigun', 'okpokporu', 'olosa' etc. Thus it can be found in various communities in Nigeria, especially the rural areas. Jatropha can grow in a wide range of soils (Achten, 2010). The documented seed provenances for Jatropha show average temperatures between 20°C and 28C° (Heller 1996; Makkar*et al.* 1997), but its occurrence has been observed in a rainfall range between 250 mm and 3000 mm (Foidl*etal.* 1996). In permanently humid regions or under irrigated conditions data on table 2 revealed that Jatropha flowers almost throughout the year (Heller 1996). The above site requirement descriptions fit into site characteristics of the estimated marginal lands in table1. This implies that the existing marginal lands have great potential for Jatropha biomass energy resources. Bearing in mind that irrigation and fertilization requirements are highly dependent on location-specific conditions. "Even under adequate rainfall, irrigation may be required for the first three years to help plant establishment" (Reinhardt et al. 2008)

The second finding was made by estimating the energy value of the estimated marginal lands. According to Achten et al. (2008), reliable data on anticipated dry Jatropha curcas seed yield per hectare per year for a given set of environmental conditions and inputs does not exist. However, Achtenet al. suggest 4-5 metric tons (tonnes) of dry seed per hectare per year as a reasonable yield estimate for a well-managed plantation with good environmental conditions. Using base case assumptions developed by The Planning Commission of India (2003) and Olaniyi (2007) for Jatropha cultivation via nursery, with an anticipation of 2,500 trees per hectare density at planting in a 2m x 2m planting grid, 1,500 grams of seed harvest per tree at full yield, or 3.75 tonnes of seed per hectare per year, seed oil content of 35% by weight with solvent extraction efficiency of 91% and Jatropha oil recovery efficiency of 32% (i.e., 35% oil content multiplied by 91% recovery efficiency). Based on above conditions, 3.125 kg seed is required to produce 1 kg Jatropha oil. Also based on this assumed oil recovery efficiency, 1.2 tonnes of Jatropha oil is expected / hectare – year. Thus the anticipated Jatropha oil recovery for the full plantation in 30,850 hectares (table 3) will be approximately 37,020 tonnes per year.

With average yield of approximately 3.5 kg of Jatropha seeds per annum per tree. 3.5kg x 2,500 trees = 8,750 kg of Jatropha seeds per hectare. 8,750 kg seeds x 33% oil = 2,887.5 kg of Jatropha oil per hectare. 2,887.5kg of Jatropha oil per hectare =2,887.5 kg x 1.12 = 3234 liters of Jatropha oil. 3234 liters of Jatropha oil x 0.95 litersbio-diesel = 3072.3 liters of bio-diesel. 3072.3 liters of bio-diesel x N128 (pump price of diesel) =N393, 254.4 from bio-diesel sales per hectare. N393, 254.4 x 30,850 hectare =N12, 131,898,240 gross profit. That's over N12 billion in bio-diesel sales per annum from just a 30,850hectares high yield planting program.

In the third place a case scenario analysis of substituting fossil fuel in BRT with biodiesel was carried out. Envisaging or prospecting integrated bio-scape energy solution project driven by Jatropha in Lagos metropolis, this section examines a case scenario analysis of substituting fossil fuel in Bus Rapid

Transit (BRT) with biodiesel. Having prospectively projected the future of total biomass production on marginal lands to be 5 ton dry matter ha-1 yr-1 (seeds only) (spacing 2m × 2m) (194, 638, 511.5 litres from 30,850 hectares per annual) analyzing fossil fuel substitution in BRT is imperative in order to estimate CO_2 sequestration rate analogous to climate change mitigation and reduction rate. A BRT experience report by Peter Danielson of Volvo Global Product Planning and Strategy revealed that operational speed and fuel consumption of BRT bus in a general city are as follow; 21 km/hr. and 62 lit/100km respectively.

Comparing this report with Lagos BRT-Lite Summary Evaluation Report (LAMATA, 2010) a demand forecasts showed that over 300 buses operating at 20 second headways would be needed to fully satisfy demand. The report further revealed that BRT-Lite runs seven days a week, 06:00-22:00 (16 hrs. per day) weekdays with reduced hours of operation at weekends on a 22km highway corridor. The average journey time is estimated to be 55minutes in both corridors and directions (that is considering the minimum and maximum journey time in both peak and off-peak journey times and in both north and south bound journey).

Using average speed of 21km/hrs, as estimated above a BRT bus in Lagos covers 336km/day (21x16). And using 62lit/100km a single BRT bus in Lagos uses 208.32litres of fuel in a day. This means that average daily fuel consumption of BRT buses in Lagos when operating in full capacity is given by 208.32litres x 300 buses = 62, 496 litres. When this figure is multiplied by 365 days in a year the annual fuel consumption of BRT buses in Lagos will be given as 62, 496 x 366 = 22, 873, 536 litres whereas the estimated annual biodiesel to be produced from marginal land in Lagos metropolis is given as **194, 638, 511.5** litres. This leaves the production system with an annual reserve of 171, 764, 975.5 litres of biodiesel. Alternatively this reserve can be used to power operational vehicles of Lagos state MDAs or converted to light energy for use in public offices.

Following an ECMT report in 2007 which revealed that BRT buses emits 466g of CO_2/km this study estimates that given 336km BRT daily mileage, a BRT bus in Lagos will cover a total of 336 x 366 = 122, 976km in a year. And applying this figure to the 300 Lagos BRT demand capacity buses will yield 36, 892, 800km per annual (300 buses x 122, 976km). Thus the annual CO_2 emitted by BRT buses in Lagos is given as **17,192, 044, 800g**. This figure represents the total grams of CO_2 that will be sequestrated annually by substituting fossil fuel with biodiesel in BRT in Lagos metropolis. Hence, for the Lagos metropolitan marginal lands the average annual CO_2 sequestration rate in the standing Jatropha seed biomass ha-1 is estimated to be 557, 278.60g CO_2 ha-1 yr-1.

4. Conclusion

This study concludes that by visibly integrating Jatropha in the design of Lagos metropolitan landscapes the resultant landscape restoration on the eco-sensitive marginal lands will repair the fragmented city ecological structure and revamp the natural processes and thus will enhance biofuel production and subsequently empowers carbon sequestration and resolve the climate change serendipity hoofing around the city's future. This conclusion is imperative since the lingering energy crises, climate change, environmental deterioration, urban sprawl, unemployment, biodiversity impediment, socio-cultural injustice; flooding and environmental health can be addressed using this single compendium called landscape philosophy.

It therefore recommends the entrenchment of Jatropha lead biofuel production in the climate change mitigation and adaption policy and environmental aesthetic scheme of the metropolis which can be achieved through;

Development of conceptual frame work of research and extension network for landscape philosophy and biofuel production using marginal lands; Assessment of hydrological impacts of Jatropha curcas L. and suitability studies to identify appropriate cultivation and production stream in the study area; sensitization and enlightenment programs on relationship between major human activities on landscape and its impact on the general ecosystem and livability of cities and, ensuring that government agencies in charge of environment, transportation sector, urbanization, energy sector, poverty alleviation and urban management etc. work together under a sustainable plan that is holistic in approach.

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